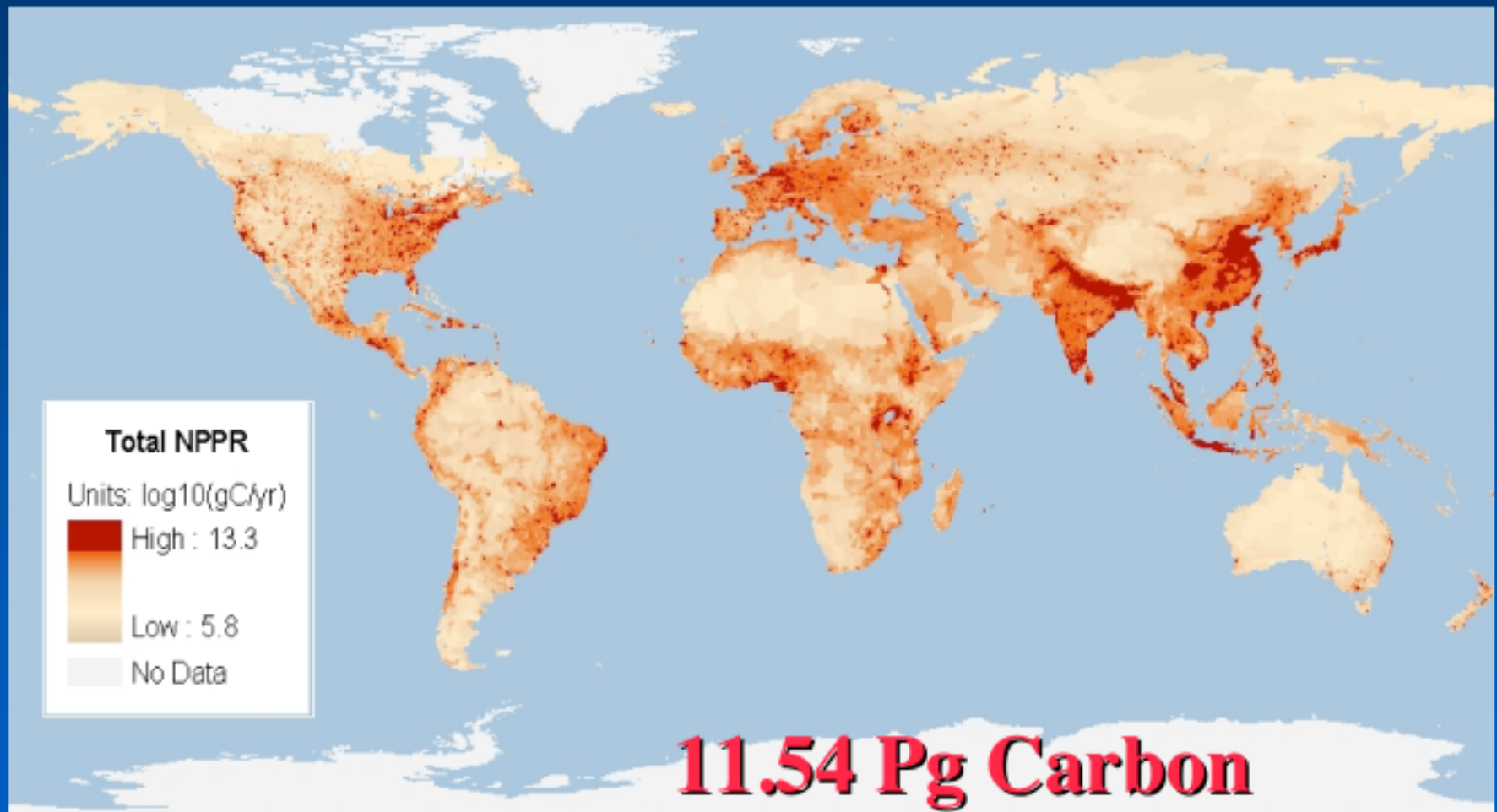
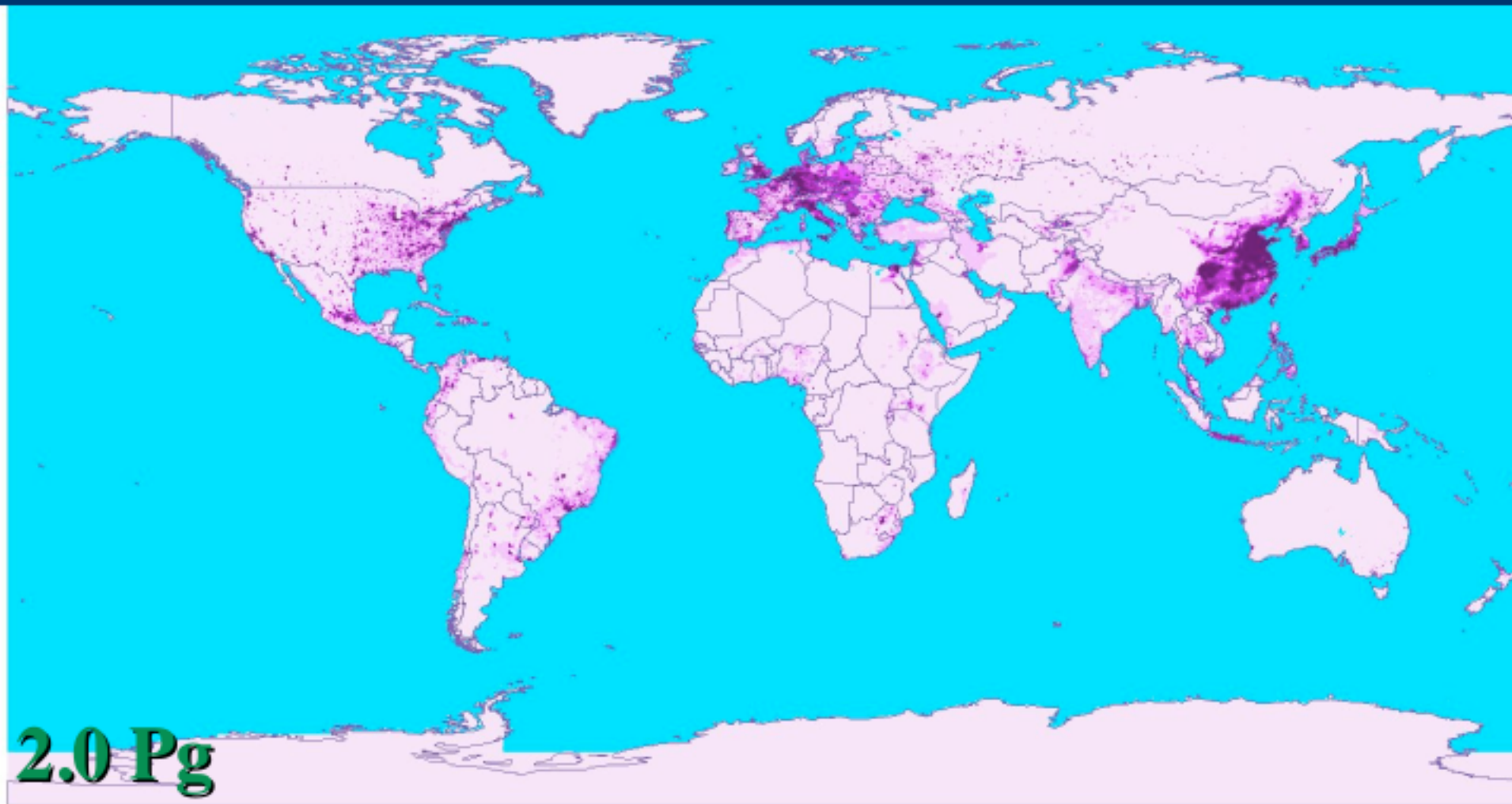


# Annual Human NPP Carbon Demand

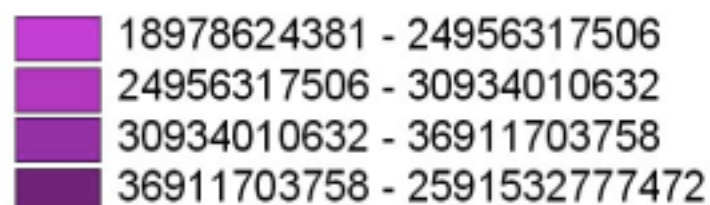
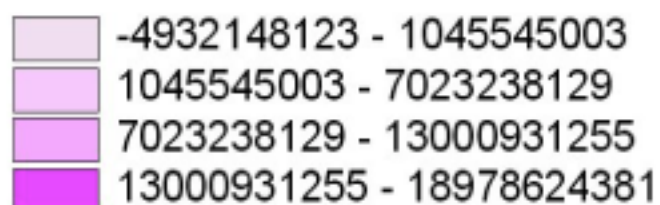
Terrestrial NPP Required for Food and Fiber (1995)



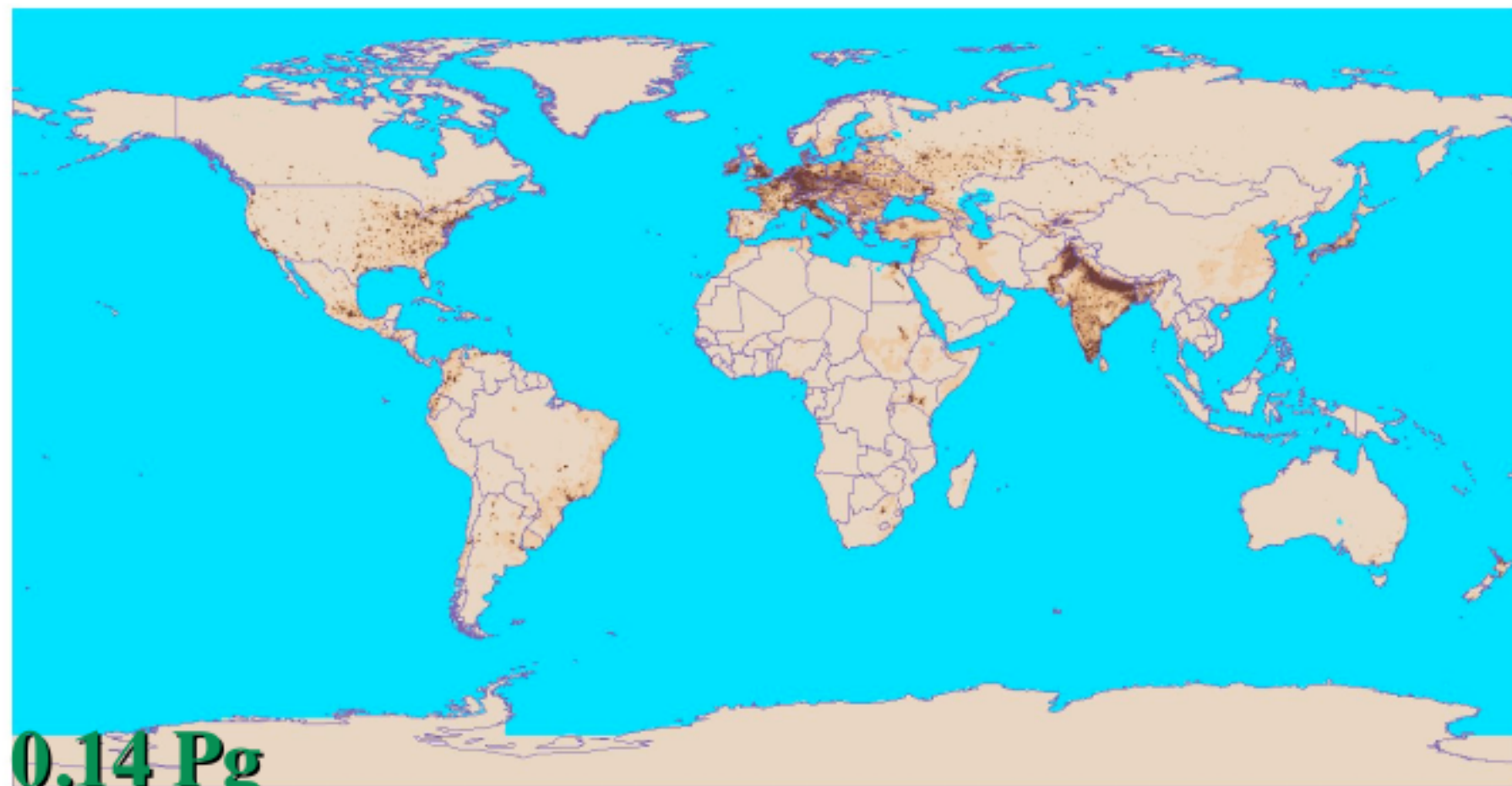
## NPP Required (g) - Meat Consumption (1995)



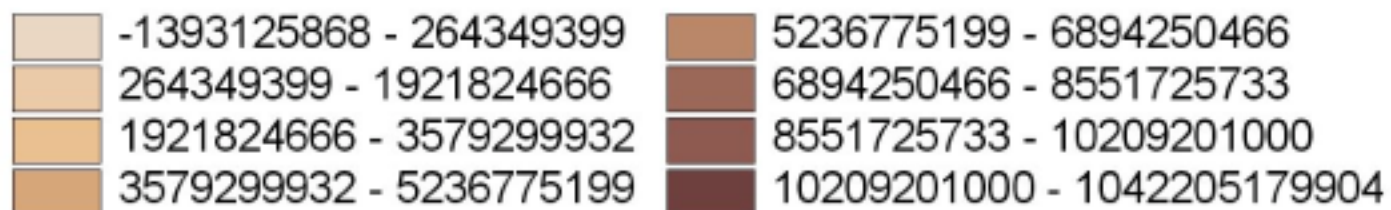
**MEAT**



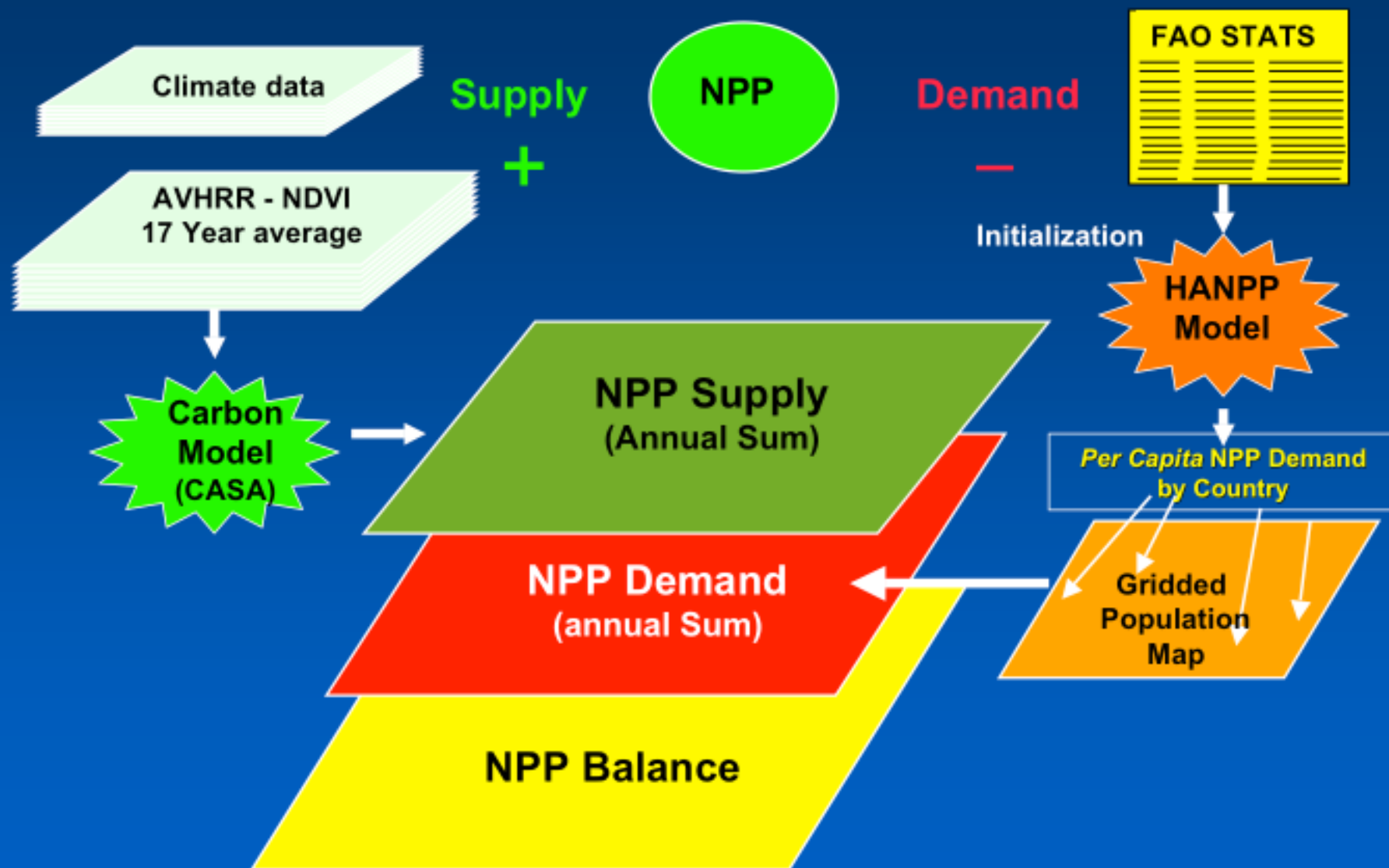
## NPP Required (g) - Milk Consumption (1995)



**MILK**

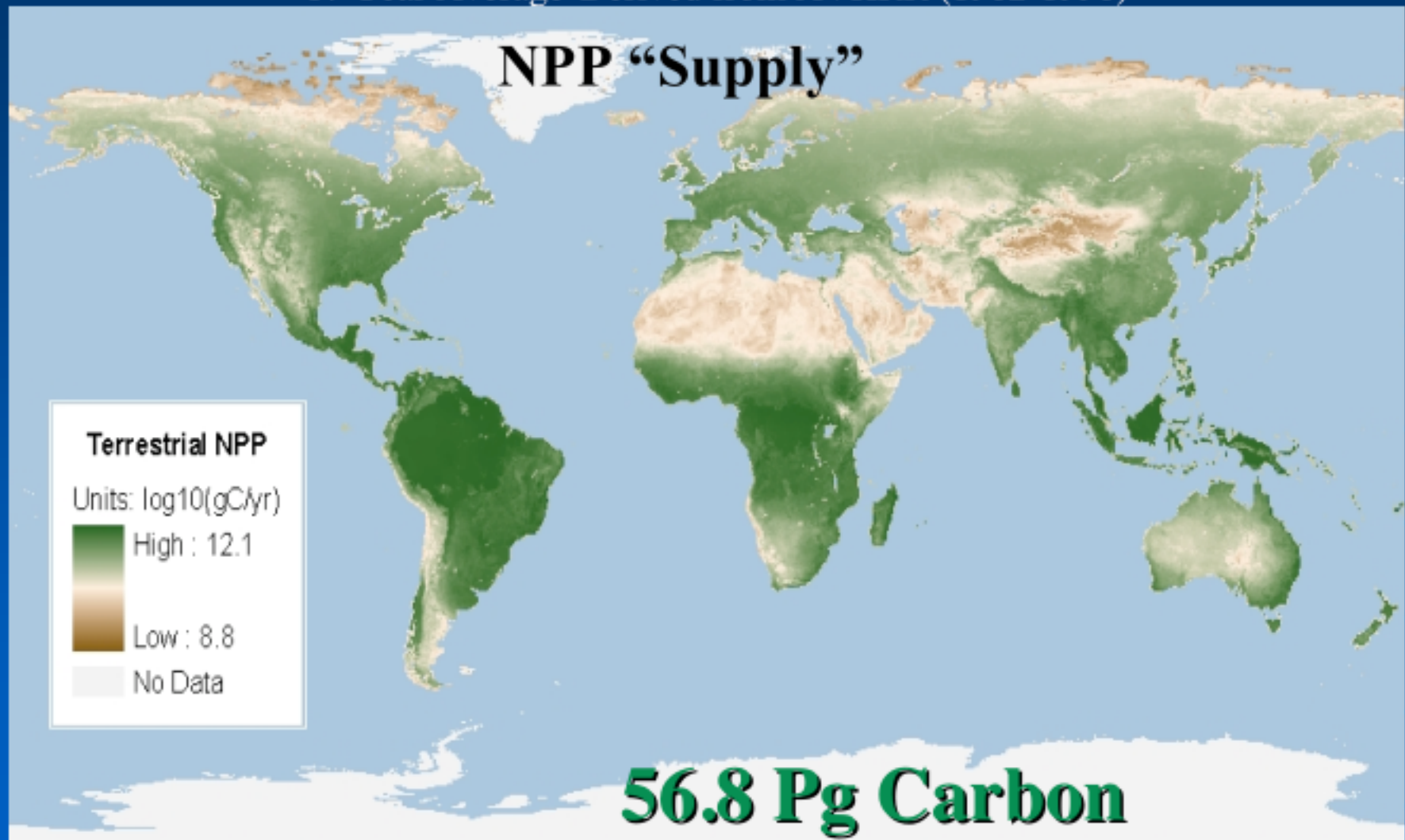


# Comparing NPP Carbon Supply and Demand



# Annual Terrestrial Net Primary Production

17 Year Average Derived from AVHRR (1982-1998)



# NPP Demand as a Percent of NPP Supply



At grid cell level demand can greatly exceed local production

# Annual NPP Carbon Demand

Human Population 1995 (5.69 Billion people)

Consumed Products (Pg Carbon)	Low Estimate	Intermediate Estimate	High Estimate
Vegetal Food	0.89	1.73	2.95
Meat	1.69	1.92	2.21
Milk	0.15	0.27	0.43
Eggs	0.09	0.17	0.26
Human Food (subtotal)	2.83	4.09	5.85
Paper	0.20	0.28	0.38
Fiber	0.32	0.37	0.42
Wood Products (including fuel)	4.64	6.81	8.15
Human Commodities (subtotal)	5.17	7.45	8.95
Total "Demand"	8.00	11.54	14.81
Demand as % of Supply (56.8 Pg)	14%	20%	26%

# Regional NPP Carbon Supply versus Demand

## (Intermediate Estimate of Demand)

Region	Population (millions)	Per Capita NPP Demand (MT C)	Regional NPP Supply ( Pg C)	Regional NPP Demand ( Pg C)	Demand % Supply
Africa	742	2.08	12.50	1.55	12%
East Asia	1400	1.37	3.02	1.91	63%
South-Central Asia	1360	1.21	2.04	1.64	80%
Western Europe	181	2.86	0.72	0.52	72%
North America	293	5.40	6.67	1.58	24%
South America	316	3.11	16.10	0.98	6%

$$I = PAT$$

- The overall ecological impact [ **I** ] of human activities involves the tight interplay of population size [ **P** ], consumption levels [ **A**, for “affluence”], and the technologies employed [ **T** ] (Holdren and Ehrlich, 1976).

## How HANPP Changes as a Function of: Population, Affluence, and Technology

Scenario	P*	A**	T***	HANPP (PgC)
1	↑	—	—	17.42
2	—	↑	—	20.19
3	—	↑	↑	16.26 †
4	↑	↑	—	31.59
5	↑	↑	↑	25.5 †

↑(increase), — (no change from the baseline 1995 intermediate estimate).

\* Population increase from 5.69 Billion (global population in 1995) to 8.92 Billion (estimated global population in 2050; Ref 18).

\*\* Affluence increase applies average *per capita* consumption of industrialized countries (in 1995) for all countries.

\*\*\* Technology increase applies technological efficiencies of industrialized countries (in 1995) to all countries.

† *Per capita* fuel wood use in developing countries reduced to average for industrialized countries in 1995.

# Concluding Remarks

- **Human NPP appropriation is a powerful measure of aggregate human impacts on the biosphere.**
- **Global NPP demand is 20% of supply with large regional and local variation:**
  - **6% (South America) to over 70% (Europe and Asia), and from near 0% (e.g., central Australia) to over 30,000% (e.g., New York City).**
- **Spatial data on NPP supply and demand illustrate the degree to which local populations depend upon NPP “imports.”**
- **The HANPP model structure allows *quantitative* assessment of changes and potential impacts to NPP-carbon use resulting from different policy and development scenarios.**

# What's Next?

*Going to the Source. NPP Demand and Land Cover.*  
From where to where and the implications of increasing demand?



# What's Next?

*Going to the Source. NPP Demand and Land Cover.*

As human populations and *per capita* consumption increase, global NPP demand will continue to rise.

- **Where are NPP source areas and how are they managed?**
  - High resolution MODIS NDVI and Continuous fields.
- **What is the fate of HANPP?**
  - Transport, trade, and end use (carbon turnover times)?
- **How much can humans increase the NPP “supply” of the planet?**
  - What is Earth's maximum potential NPP yield - *Soils*.
- **How will the land cover changes required to meet growing NPP demand affect regional and global climate?**
- **How will increasing NPP demand affect biodiversity and ecosystem services?**

## 2004-2003 Publications

Marc L. Imhoff , Lahouari Bounoua, Ruth DeFries, William T. Lawrence, David Stutzer, Compton J. Tucker, and Taylor Ricketts (in press). The consequences of urban land transformation for net primary productivity in the United States. *Remote Sensing of Environment*.

Luck, G.W., T.H. Ricketts, G.C. Daily, M. Imhoff , 2004. Spatial conflict between people and biodiversity. *Proceedings National Academy of Sciences*, vol. 101, No. 1, pp 182-186 ([www.pnas.org/cgi/doi/10.1073/pnas.2237148100](http://www.pnas.org/cgi/doi/10.1073/pnas.2237148100)).

L. Bounoua, R. S. Defries, M. L. Imhoff, and M. K. Steininger, 2003. Land use and local climate: A case study near Santa Cruz, Bolivia. *Meteorology and Atmospheric Physics*, Publisher: Springer-Verlag Wien, ISSN: 0177-7971, DOI: 10.1007/s00703-003-0616-8.

Ricketts, T. and M. Imhoff. 2003. Biodiversity, urban areas, and agriculture: locating priority ecoregions for conservation. *Conservation Ecology* 8(2): 1. [online] URL: <http://www.consecol.org/vol8/iss2/art1>

Rosenqvist, A., Milne T. Lucas R., Imhoff, M. and Dobson C., 2003. *A review of remote sensing technology in support of the Kyoto Protocol*. *Environmental Science & Policy*, (October 2003) Vol. 6, No. 5, pp 441-455.

Rosenzweig, M.L., W. Turner, J.G. Cox, and T.H. Ricketts. 2003. Estimating diversity in unsampled habitats of a biogeographical province. *Conservation Biology* 17.